UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/820,654	04/08/2004	Mark S. Haberbusch	35494US1	8021

116 7590 10/10/2006

PEARNE & GORDON LLP
1801 EAST 9TH STREET
SUITE 1200
CLEVELAND, OH 44114-3108

EXAMINER	
PETTITT, JOHN F	
ART UNIT	**PAPER NUMBER**
3744	

DATE MAILED: 10/10/2006

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No.	Applicant(s)	
	10/820,654	HABERBUSCH ET AL.	
	Examiner	Art Unit	
	John Pettitt	3744	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *05 September 2006*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-53* is/are pending in the application.

4a) Of the above claim(s) *49* is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-25, 30-34, 37, 39-48 and 51* is/are rejected.

7)☒ Claim(s) *26-29,35-36,38,50, and 52-53* is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on *08 April 2004* is/are: a)☐ accepted or b)☒ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)

2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)

3) ☒ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08) Paper No(s)/Mail Date *08/16/2004*.

4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____.

5) ☐ Notice of Informal Patent Application (PTO-152)

6) ☐ Other: _____.

DETAILED ACTION

Applicant's election without traverse of claims 1-48 and 50-53 in the reply filed on 09/05/2006 is acknowledged.

Drawings

The drawings are objected to as failing to comply with 37 CFR 1.84(p)(5) because they include the following reference character(s) not mentioned in the description: 330 shown in Figure 5. Corrected drawing sheets in compliance with 37 CFR 1.121(d), or amendment to the specification to add the reference character(s) in the description in compliance with 37 CFR 1.121(b) are required in reply to the Office action to avoid abandonment of the application. Any amended replacement drawing sheet should include all of the figures appearing on the immediate prior version of the sheet, even if only one figure is being amended. Each drawing sheet submitted after the filing date of an application must be labeled in the top margin as either "Replacement Sheet" or "New Sheet" pursuant to 37 CFR 1.121(d). If the changes are not accepted by the examiner, the applicant will be notified and informed of any required corrective action in the next Office action. The objection to the drawings will not be held in abeyance.

Claim Objections

Claims 14, 34-35, 37, 38, 43, and 49 are objected to because of the following informalities:

In regard to claim 14, the term "its" (line 2) introduces confusion. The examiner suggests changing "its" to --an outer surface of said tubing--.

In regard to claims 34-35, the recitation "said heat absorptive material" lacks antecedent basis; it is unclear whether this refers to the material in the first or second regenerator or both. The examiner assumes the applicant is referring to both and suggests using the phrase --said first and second heat absorptive material--

In regard to claims 37-38, 43, and 49-50 commas appear to be missing. Claim 37-line 6. Claim 38, line 3 and 6. Claim 43, line 4. Claim 49-line 3. For example, a comma should be placed after "cold heat exchangers" in claim 37, line 6.

Appropriate correction is required.

Claim Rejections - 35 USC § 102

The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> (e) the invention was described in (1) an application for patent, published under section 122(b), by another filed in the United States before the invention by the applicant for patent or (2) a patent granted on an application for patent by another filed in the United States before the invention by the applicant for patent, except that an international application filed under the treaty defined in section 351(a) shall have the effects for purposes of this subsection of an application filed in the United States only if the international application designated the United States and was published under Article 21(2) of such treaty in the English language.

Claims 1, 9-10, and 39-41 are rejected under 35 U.S.C. 102(e) as being anticipated by Royal et al. (U.S. 6,430,938 B1).

In regard to claim 1, Royal et al. ('938) teach a vertically oriented OPTR (components above storage tank shown in Figure 1), storage vessel (20), and a cooling

system (components above storage tank shown in Figures 1 and 2) adapted to counteract heat transfer from the ambient environment.

In regard to claims 9-10, Royal et al. ('938) teach a body (50) projecting directly into hydrogen storage volume (2) (Figure 2). In addition, any body which extends from a surface and through which heat is transferred can be viewed as a fin. Therefore, item 50 in Royal et al. ('938) teaches a fin as well.

In regard to claim 39, the system of Royal et al. ('938) is capable of maintaining liquid hydrogen in the storage vessel at 20 K at steady state such that substantially no venting of vaporized hydrogen is necessary (column 2, lines 36-40).

In regard to claim 40, Royal et al. ('938) teach an oscillatory gas pressure power source coupled to said orifice pulse tube refrigerator; the oscillatory gas pressure power source is adapted to provide periodic pressure surges in a working fluid to drive the OPTR to generate refrigeration power (column 2, lines 48-61).

Claim Rejections - 35 USC § 103

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

Claim 41 is rejected under 35 U.S.C. 103(a) as being unpatentable over the obvious modification of Royal et al. (US 6,430,938 B1). Royal et al. ('938) teach a gas

compressor coupled to an OPTR capable of providing periodic pressure surges in a working fluid to drive the OPTR. Royal et al. ('938) do not explicitly state that the gas compressor could be an electric gas compressor. However, electric gas compressors are extremely common in the art and are convenient to use in many applications because of the availability of electricity. Therefore, it would have been obvious to one of ordinary skill in the art, at the time the invention was made, to use an electric gas compressor to provide the pressure surges to the OPTR of Royal et al. ('938) because of the easy of obtaining electric power.

Claims 11 is rejected under 35 U.S.C. 103(a) as being unpatentable over Royal et al. (U.S. 6,430,938 B1) in view of C. Wang et al. (Cryogenics, 1997, Vol. 37, Issue 12, p. 857-863).

Royal et al. ('938) teaches most of the limitations of the claim. However Royal et al. ('938) do not teach the OPTR comprising a two-stage OPTR that is vertically oriented. Wang et al. (p.857) teach a vertically oriented two stage OPTR (Figure 1(d)) with each of the first and second stage refrigeration units comprising a respective regenerator (12 and 13), cold heat exchanger (17 and 20), pulse tube (16 and 19), hot heat exchanger (15 and 18), primary orifice (5 and 7), inertance tube (8 and 11) and reservoir volume (9 and 10), and each stage having a second orifice (4 and 6 or alternatively 5 and 7 can act as primary and secondary valves) connecting the respective hot heat exchanger to the transfer tube. All these two stage components

being provided to reach lower temperatures by first cooling the thermoshield (30) to allow the second stage cold heat exchanger to reach lower temperatures.

Therefore, it would have been obvious to combine the storage vessel, compressor (11), transfer tube (between 11 and 23), and cooling system (Figure 2) of Royal et al. ('938) with the vertically two stage OPTR of Wang et al. (p.857) to allow for the second stage cold heat exchanger to reach lower temperatures and to introduce the inertance provided by the inertance tubes of Wang et al. (p.857) to provide a greater shift in phase--which improves the OPTR's cooling performance.

Claims 1-8, 12-24, 32-34, 37, 40-41, 43-44, and 46-48 are rejected under 35 U.S.C. 103(a) as being unpatentable over Garnier, D. (Innovative Confinement Concepts, Berkeley California, February 24, 2000 -- ICC-2000) and A. Zhukovsky, M. Morgan, D. Garnier, A. Radovinsky, B. Smith, J. Schultz, L. Myatt, S.Pourrahimi, J. Minervini, "Design and Fabrication of the Cryostat for the Floating Coil of the Levitated Dipole Experiment (LDX)", IEEE Transactions on applied superconductivity, Vol. 10, No. 1, March 2000 in view of C. Wang et al. (Cryogenics, 1997, Vol. 37, Issue 12, p. 857-863).

In regard to claim 1, Garnier (ICC-2000) teaches a storage vessel (page 8, green torus sectioned in half for picture, labels have been added to the figure by the examiner to facilitate identification of the structures) and a cooling system (page 8, entire structure surrounding halved green torus) wherein the storage vessel would be capable of storing liquid hydrogen and the cooling system is adapted to counteract heat transfer to the storage vessel from the ambient environment.

Garnier (ICC-2000) does not teach an orifice pulse tube refrigerator (OPTR) to provide cooling to the cooling system. However, Wang et al. (p.857) teach an OPTR (Figure 1 (d)) for providing low temperature refrigeration. It would have been obvious to one of ordinary skill in the art, at the time the invention was made, to combine the OPTR of Wang et al. (p.857) vertically in the center of the toroidal storage vessel and cooling system of Garnier (ICC-2000) to provide a compact refrigeration system for the stored hydrogen.

In regard to claim 2, Garnier (ICC-2000) teaches the storage vessel (page 11, items 4 and 5) to be in the shape of a toroid and having an interior surface (page 11, item 4) defining a hydrogen storage volume of the storage vessel.

In regard to claim 3, Garnier (ICC-2000) teaches a first thermal jacket (page 8, inner dark blue torus) exterior to and substantially enclosing said storage vessel and a second thermal jacket (page 8, second light blue torus) exterior to and substantially enclosing said first jacket.

In regard to claim 4, Garnier (ICC-2000) teaches super insulation (page 11, item 10 - multilayer insulation) disposed around and substantially enclosing said storage vessel and first thermal jacket. Additionally, the use of multilayer insulation to insulate cryogenic refrigerators and systems is very well known in the art.

In regard to claim 5, Wang et al. (p.857) teach that the second stage OPTR operates at a lower temperature than the first stage. In cooling the thermal jackets of the storage vessel with a two-stage OPTR, it would have been obvious to one of ordinary skill in the art to employ the first refrigerant from the first stage OPTR to cool

the second thermal jacket and the second stage refrigerant from the second stage OPTR to cool the first thermal jacket to take advantage of the staging capacity of the two-stage OPTR. This is the reason staged refrigerators are employed in all situations-to further refrigerate refrigerated spaces to obtain lower temperatures at the last stage cold heat exchanger location. The combination as such provides the expected result.

In regard to claim 6, see claim 5 above. This is the normal mode of operation (staging) of a two-stage OPTR as it is connected to the two thermal jackets and would involve routine and ordinary skill in the art.

In regard to claims 7-8, the OPTR of Wang et al. (p.857) is capable of reaching a first temperature of 100-60 K and a second temperature of 13-20 K (Figure 2, page 861).

In regard to claim 12, Garnier (ICC-2000) teaches a first thermal jacket (page 11, items 2) in the shape of a toroid located concentrically adjacent and substantially enclosing the liquid hydrogen storage vessel (page 11, items 4 and 5).

In regard to claim 13, Garnier (ICC-2000) teaches that the first thermal jacket comprises a length of tubing coiled in the shape of a toroid (page 11, items 2) around the storage vessel (page 11, items 4 and 5) and adapted to accommodate a flow of a first refrigerant fluid.

In regard to claim 14, Garnier (ICC-2000) teaches that the tubing has a flat side extending longitudinally; said tubing is in direct contact with the storage vessel (page 11, item 5) while being wound around the torus of the storage vessel (page 11, item 5).

In regard to claim 15, it is well known in the art to solder or braze heat exchanger components to the items being cooled. In the present case the flush orientation of the tubing relative to the toroidal storage vessel (page 11, item 5) of Garnier (ICC-2000) indicates such bonding.

In regard to claim 16, see claims 5-6 above.

In regard to claim 17, see claim 3 above.

In regard to claim 18, Garnier (ICC-2000) teaches that the second thermal jacket comprises a length of tubing (page 8, pink torus) that is coiled in the shape of a toroid and is adapted to accommodate flow of a second refrigerant fluid. Note that the second thermal jacket is not coiled in the same manner as the first thermal jacket (page 11, item 2) but is still coiled as claimed.

In regard to claim 19, Wang et al. (p.857) teach a two stage OPTR wherein the second stage OPTR operates at a lower temperature than the first OPTR. See claims 5-6 above.

In regard to claim 20, again see claims 5-6 above; adapting flow passages to the cold heat exchangers of the respective stages would have been the obvious implementation of the two-stage OPTR of Wang et al. (p.857).

In regard to claim 21, Garnier (ICC-2000) teaches super insulation (page 11, item 10) disposed around and substantially enclosing the storage vessel and the first thermal jacket. Garnier (ICC-2000) does not show that the second thermal jacket is between super insulation layers. But in light of the obvious use of the first stage OPTR to provide a first level of refrigeration to the second thermal jacket's interior (i.e.

Staging), it would have been obvious to a person having ordinary skill in the art, at the invention was made, to insulate the second thermal jacket with super-insulation to reduce the heat leak into the second thermal jacket thus reducing the heat load requirements of the first stage OPTR, allowing a less powerful OPTR to be used in reaching the required first stage temperature level.

In regard to claim 22, due to the geometry of Garnier's (ICC-2000) storage vessel and cooling system, one of ordinary skill in the art would recognize that the most compact and suitable location of the OPTR would be the center of the torus assembly.

In regard to claim 23, Garnier (ICC-2000) teaches an outer housing (page 8, large blue vacuum vessel) that defines a primary vacuum chamber with the storage vessel and cooling system disposed within the vacuum chamber.

In regard to claim 24, the combination of the OPTR of Wang et al. (p.857) within the center of the torus of the storage vessel and cooling system of Garnier (ICC-2000) would lead to the "operative cold" components of the OPTR being within the primary vacuum chamber of Garnier (ICC-2000).

In regard to claim 32, Wang et al. (p.857) implicitly teach the second regenerator having a second heat absorptive material with a volumetric heat capacity of greater than 0.23 J/cm^3-K at 13-14 K and of at least 0.5 J/cm3-K at 18-20 K (for support that this information is implicit to Wang et al. (p.857) see "Numerical analysis of 4K pulse tube coolers: Part I. Numerical Simulation", Cryogenics, C. Wang, 1997, Vol. 37, issue 4, Figure 3) as well as a porosity of 0.2-0.5 (also implicitly taught by Wang et al. (p.857) and proven by C. Wang, Vol. 37, issue 4, p.211, 2nd paragraph).

In regard to claim 33, Wang et al. (p.857) teach the use of rare earth metal for the second heat absorptive material in the second regenerator (paragraph 4, p. 857).

In regard to claim 34, Wang et al. (p.857) teach that the first and the second regenerator materials are Erbium compounds (paragraph 4, p. 857).

In regard to claim 37, see claim 22 above.

In regard to claim 40-41, Wang et al. (p.857) teach a compressor that is coupled to the OPTR and is adapted to provide periodic pressure surges to the working fluid and generate refrigeration power. The compressor is a Leybold Model RW 6000 and thus is an electric gas compressor (p. 858, top right).

In regard to claim 43, Wang et al. (p.857) teach a two stage orifice pulse tube refrigerator (OPTR) wherein the orifice pulse tube refrigerator comprises a first stage pulse tube refrigerator and a second stage pulse tube refrigerator (Figure 1, (d)) each unit having a respective regenerator (12 and 13), cold heat exchanger (17 and 20), hot heat exchanger (15 and 18), and pulse tube (16 and 19). The net refrigeration power for each of the first and second stage refrigeration units is generated at the respective first and second stage cold heat exchangers (17 and 20). The temperature of the second stage cold heat exchanger operates at a lower temperature than the first stage cold heat exchanger.

In regard to claim 44, the OPTR of Wang et al. (p.857) is capable of generating more than 4-6 Watts of refrigeration while the first cold heat exchanger is operating at 60-100 K and the second cold heat exchanger is operating at 13-20 K (p. 861 - 2nd paragraph; Fig. 3).

In regard to claim 46, Garnier (ICC-2000) teaches a toroidal storage vessel and cooling system, the storage vessel (page 8, green torus sectioned in half for picture) having an interior capable of storing liquid hydrogen. The cooling system comprises a first thermal jacket (page 8, inner dark blue torus) in the shape of toroid enclosing the storage vessel, and a second thermal jacket (page 8, light blue torus) in the shape of a toroid enclosing the first thermal jacket. Garnier (ICC-2000) does not teach a two-stage orifice pulse tube refrigerator to provide the cooling to the thermal jackets.

Wang et al. (p.857) teach a two stage orifice pulse tube refrigerator (OPTR) wherein the orifice pulse tube refrigerator comprises a first stage pulse tube refrigerator and a second stage pulse tube refrigerator (Figure 1, (d)) each unit having a respective regenerator (12 and 13), cold heat exchanger (17 and 20), hot heat exchanger (15 and 18), and pulse tube (16 and 19). The net refrigeration power for each of the first and second stage refrigeration units is generated at the respective first and second stage cold heat exchangers (17 and 20). The temperature of the second stage cold heat exchanger operates at a lower temperature than the first stage cold heat exchanger. Thus Wang et al. (p.857) teach a two-stage refrigeration system for the purpose of reaching lower temperatures with an OPTR system (paragraph 2, p.857).

Therefore it would have been obvious to a person having ordinary skill in the art, at the time the invention was made, to combine the OPTR of Wang el al. (p.857) within the center of the storage vessel and cooling system of Garnier (ICC-2000) for the purpose of providing a compact refrigeration system for refrigerating hydrogen at a low temperature to prevent the hydrogen from evaporating.

In regard to claim 47, Garnier (ICC-2000) teaches a first thermal jacket comprises a first length of tubing coiled in the shape of a toroid (page 11, light blue tubes, item 2); a second thermal jacket comprising a second length of tubing which is in shape of a toroid (page 11, item 9) and substantially encloses the first thermal jacket within the interior of the second length of tubing. See claim 18 above as well.

In regard to claim 48, see claim 21 above.

Claim 25 is rejected under 35 U.S.C. 103(a) as being unpatentable over Garnier, D. (Innovative Confinement Concepts, Berkeley California, February 24, 2000) in view of C. Wang et al. (Cryogenics, 1997, Vol. 37, Issue 12, p. 857-863) **as applied to claims 1 and 23 above and further in view of** A. Zhukovsky, M. Morgan, D. Garnier, A. Radovinsky, B. Smith, J. Schultz, L. Myatt, S.Pourrahimi, J. Minervini, "Design and Fabrication of the Cryostat for the Floating Coil of the Levitated Dipole Experiment (LDX)", IEEE Transactions on applied superconductivity, Vol. 10, No. 1, March 2000

Garnier (ICC-2000) does not explicitly teach that the primary vacuum level is less than 10^{-4} torr. However, Garnier et al. (IEEE Mar 2000) teaches that the primary vacuum level is less than 10^{-4} torr for the well known purpose of thermally insulating a cryostat from ambient environment. Therefore, it would have been obvious to one of ordinary skill in the art, at the time the invention was made, to insulate the cryostat of Garnier (ICC-2000) with a primary vacuum of 10^{-4} torr for the purpose of effectively reducing the ambient heat leak.

Claims 30-31 are rejected under 35 U.S.C. 103(a) as being unpatentable over Garnier, D. (Innovative Confinement Concepts, Berkeley California, February 24, 2000) and C. Wang et al. (Cryogenics, 1997, Vol. 37, Issue 12, p. 857-863) as applied to claim 1 above, and further in view of Burt (US 5,286,345).

In regard to claim 30, Wang et al. (p.857) teach the first stage regenerator having a first heat absorptive material therein (paragraph 4, p.857). The first heat absorptive material having a conductivity of not more than 28 W/m-K at 60-100 K, and having a volumetric specific heat of at least 1 J/cm^3-K at 60-100K (implicitly taught by the use of Erbium compounds). Wang et al. (p.857) do not teach using a regenerator with a porosity of at least 0.5.

Burt ('345) teaches the use of screens with porosities of 0.60 (column 3, lines 40-50, column 4, lines 1-7). It would have been obvious to one of ordinary skill in the art, at the time the invention was made, to use the regenerator screens of Burt ('345) within the first regenerator of Wang et al. (p.857) to provide a low pressure drop through the first regenerator of the OPTR thus increasing the refrigeration efficiency of the OPTR.

In regard to claim 31, Wang et al. (p.857) teach the first heat absorptive material being a plurality of layers of stainless steel screen (p.859, under "Regenerator"). The pressure drop through the first stage regenerator was neglected as being too small to consider by the authors. In consideration that the claim does not recite a limitation on the mass flow rate through the regenerator the pressure drop within the regenerator is certainly capable of being less than 1 psi.

Claim 45 is rejected under 35 U.S.C. 103(a) as being unpatentable over Royal et al. (U.S. 6,430,938 B1) as discussed above for claim 1, and further in view of K. Pehr et al. ("Liquid hydrogen for motor vehicles - the world's first public LH_2 filling station", *International Journal of Hydrogen Energy*, Volume 26, Issue 7, July 2001, Pages 777-782, K. Pehr, P. Sauermann, O. Traeger and M. Bracha). Royal et al. ('938) teach a hydrogen storage and delivery system comprising a vertically oriented OPTR (components above storage tank shown in Figures 1-2); a storage vessel (2); a cooling system (components surrounding storage tank shown in Figure 1 and 2) adapted to counteract heat transfer from the ambient environment. Royal et al. ('938) do not teach a hydrogen-powered automobile.

K. Pehr et al. (2001) teach a hydrogen-powered automobile (section 5, LH2 vehicles, p.780) for the purpose of transportation. It would have been obvious to one having ordinary skill in the art, at the time the invention was made, to combine the OPTR and cooling system of Royal et al. ('938) with the hydrogen powered car of K. Pehr et al. (2001) for the purpose of eliminating evaporation of the hydrogen fuel as taught by Royal et al. ('938) (column 1, 3rd paragraph) so that the fuel could be utilized rather than boiled off by ambient heat leak.

Claims 51 is rejected under 35 U.S.C. 103(a) as being unpatentable over Royal et al. (U.S. 6,430,938 B1) and C. Wang et al. (Cryogenics, 1997, Vol. 37, Issue 12, p. 857-863) as applied to claim 46 above, and further in view of Foster et al. ("Development of a High Capacity Two-Stage Pulse Tube Cryocooler", Cryocoolers 12, March 1, 2003,

p.225-232). Wang et al. (p.857) do not teach an electric flexure bearing linear drive compressor.

Foster et al. (p.225) teaches the use of an electric flexure bearing linear drive compressor to provide the pressure pulses for a two-stage OPTR. Linear compressors are known to provide greater reliability. Therefore, it would have been obvious to one of ordinary skill in the art, at the time the invention was made, to combine the toroidal storage vessel of Garnier (ICC-2000) with the two stage OPTR of Wang et al. (p. 857) with the electric flexure bearing linear compressor as taught by Foster et al. (p.225) to provide a compression source with higher reliability.

Claim 42 is rejected under 35 U.S.C. 103(a) as being unpatentable over Garnier, D. (Innovative Confinement Concepts, Berkeley California, February 24, 2000) and C. Wang et al. (Cryogenics, 1997, Vol. 37, Issue 12, p. 857-863) as applied to claims 1 and 40-41 above and further in view of Foster et al. ("Development of a High Capacity Two-Stage Pulse Tube Cryocooler", Cryocoolers 12, March 1, 2003, p.225-232).

In regard to claim 42, see claim 51.

Allowable Subject Matter

Claims 26-29, 35-36, 38, 50, and 52-53 are objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims.

Remarks

The prior art made of record and not relied upon is considered pertinent to applicant's disclosure.

The teachings within Garnier (ICC-2000) are further established and explained in a detailed description of the same project:

A. Zhukovsky, M. Morgan, D. Garnier, A. Radovinsky, B. Smith, J. Schultz, L. Myatt, S.Pourrahimi, J. Minervini, "Design and Fabrication of the Cryostat for the Floating Coil of the Levitated Dipole Experiment (LDX)", IEEE Transactions on applied superconductivity, Vol. 10, No. 1, March 2000.

Much of the design information implicitly provided in Wang et al. (p.857) relative to the porosity of the regenerators, the properties of the regenerator material, etc are explicitly taught in the following three documents:

"Numerical analysis of 4K pulse tube coolers: Part I. Numerical Simulation", Cryogenics, C. Wang, 1997, Vol. 37, issue 4, p.207-213.

"Numerical analysis of 4 K pulse tube coolers: Part II. Performances and internal processes", Cryogenics, C. Wang, 1997, Vol 37, issue 4, p.215-220.

"Thermal Conductivities and Lorenz Functions of Dy, Er, and Lu Single Crystals", *Physical Review*, Vol. 174, No. 2, 10 October 1968, D.W. Boys and S. Legvold, p.377-384.

The following sources teach that multiple stage refrigeration is commonly relied on to decrease the lowest temperature of a refrigeration system:

Chan et al. (US 5,107,683) column 1, lines 22-25.

Hiresaki et al. (US 5,642,623) column 1, lines 23-27.

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to John Pettitt whose telephone number is 571-272-0771. The examiner can normally be reached on M-F 8a-4p.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Cheryl Tyler can be reached on 571-272-4834. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

JFP III
September 15, 2006

Cheryl Tyler
CHERYL TYLER
SUPERVISORY PATENT EXAMINER